PATENT SPECIFICATION

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(54) SWING-PAD BEARING

(71) I, JEROME GREENE, of 1608 Comanche Road, Arnold, Maryland 21012, United States of America; a citizen of the United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:

In the construction of conventional fixed geometry bearings of the fluid-wedge sliding surface type, the effects of loading on the surface is to reduce the fluid wedge thickness. This restricts replenishment of the lubricant.

In pivoting pad sliding surface bearings, the effects of loading on the surface of the pads and the lubricant viscous friction cause the fluid wedge of the lubricant to diverge in the direction of the movement of the rotating member with the result that the leading edge of the wedge tends to close and restrict this replenishment of the lubricant. This results from the direction of forces on the pads. This tendency is reduced by the deformability of the pads under operating conditions. The result is bearings of limited load carrying capacity and with a limited ability to maintain a lubricant wedge thereby to prevent an operating condition known as "stick-slip".

It is an object of the present invention to provide a hydrodynamic bearing arrangement for supporting a movable load applying member in low-friction relationship in the presence of a lubricating fluid medium, which at least minimises the above-mentioned disadvantages.

According to the present invention there is provided a hydrodynamic bearing arrangement for supporting a movable load applying member in low-friction relationship in the presence of a lubricating fluid medium, said bearing arrangement comprising at least one bearing pad disposed between said movable load applying member and a relatively stationary support structure, the bearing pad including a swingable face portion disposed adjacent said movable member, and means for supporting said face portion for swinging motion abiut an axis of swinging motion spaced from said face portion and on the same side of said face portion as said movable member said face portion of each pad being swingable to a dynamically stable inclined position under the combined influences of friction and load forces acting thereon in the presence of a lubricant fluid.

The result of this location of the center of curvature of the pad is that under the forces of friction and the pressure of the load, the pads swing so as to produce a wedge converging in the direction of movement of the moving member. Motion of the pads is usually very slight, the wedge angle being minute, and the face of the pad remains substantially parallel to the surface of the rotating load member when the pad is mounted on the stationary member. Such a parallelism arrangement provides for a maximum-load carrying capacity and prevents "stick-slip". The bearing of the present construction is inherently capable of accommodating to rotation of the load member in either direction and can be designed either as a flat thrust bearing, a cylindrical bearing or a combination of the thrust and cylindrical bearing.

The present invention will be further illustrated, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a simplified sketch of a portion of a pivoted pad thrust bearing showing the effects of pressure and friction forces on the bearing pad,

Fig. 2 is a simplified sketch of a portion of a bearing showing the pad elements of

the thrust version of the present invention and the effects of pressure and friction forces on the bearing pad.

Fig. 3 illustrates a portion of a bearing utilizing a thrust pad constructed according to this invention.

Fig. 4 illustrates the present invention applied to a cylindrical bearing.

Fig. 5 illustrates the present invention applied to a flat thrust type bearing.

Fig. 6 is a diagram showing fluid pressure distribution on the face of the pad.

The illustrations in Figs. 2, 3 and 6 are greatly exaggerated for the purpose of clearly showing the principle involved.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, FIG. 1 shows a portion of a conventional pivoted pad bearing having a pad 11 that can pivot on pivot 12 and a moving member 13 which moves in the direction of arrow 14. The movement of member 13 relative to member 11 shears the fluid between the members and generates the viscous frictional force indicated by arrow F. The center of load pressure of this particular pad 11 vector of the bearing is indicated by vector arrow P. The moments of these two forces about the pivot point of the pad 11 are respectively Pa and Fb, where a and b are respectively the displacements of the friction and pressure force vectors F and P from the pivot point. Under the conditions illustrated both these moments tend to pivot the pad about its pivot in a direction to close the wedge on the upstream side of the pad as shown in dotted lines. This in turn tends to cut off the flow of lubricant into the wedge and to prevent replenishment of the lubricant flowing out of the wedge, thus severely limiting the load carrying capacity of the bearing.

FIG. 2 shows the principal of operation of the bearing of this invention. In this illustration the same symbols are used to designate corresponding parts of the illustration. In this figure there is added the feature that the pad is composed of two parts, face portion 11a and base 11b which meet along an arcuate interface, faces 15, and 16, with the center of the arc at a point 17 on a line extending in the direction of the member 13, away from the member 11a. As illustrated, the center of curvature point is on a line perpendicular to the rest position of the pad 11 and at the center of the pad. The arcuate interface may be cylindrical or spherical, depending on the application of the bearing. As shown by FIG. 2, the moments of the load pressure forces and the friction forces are in the opposite direction. The distance along the line is a function of the desired curvature which is selected to establish the position of the pad at which an equilibrium condition exists between the moments due to the load force and the moments due to the viscous friction forces of the lubricant. In this discussion it is assumed that there are no friction forces generated at the interface between pad elements 11a and 11b. Under these conditions, the face 11a of the pads of the bearing, such as the one illustrated, will be swung to the dotted line position thus forming a wedge with the end opened to receive the lubricant pumped by the motion of element 13. The swinging motion of pad 11a, as illustrated includes a component of motion parallel to and in the direction of movement of member 13, and a rotational component about an axis extending into the plane of the drawings of FIGS. 2 and 3, this axis being referred to, for convenience, as an axis extending laterally transversely of the direction of movement of member 13 relative to member 11a. The magnitude of the viscous friction forces are inversely proportional to the magnitude of the gap between the pad face 11a and member 13. In addition, the magnitude of the gap is inversely proportional to the magnitude of the load force. Thus the greater the load force trying to close the gap the greater will be the friction forces generated to balance the load force. Therefore the pad self-adjusts to produce a wedge in which the replenishment lubricant can never be cut off regardless of the magnitude of the load force. As the replenishment lubricant will always be maintained, the load capacity is extremely high. The maintenance of a converging wedge under all load conditions prevents the "stick-slip" condition from occurring.

Even in the start up condition the friction forces act to counter the effects of the load forces on the bearing pad regardless of which of the two directions, clockwise or counterclockwise, the member 13 moves.

Referring to FIG. 3 there is shown a preferred embodiment of the invention in which the face 11a of the pad 11 is bonded to a section of a metal-elastomer laminate 18 which is in turn bonded to the base 11b of the pad 11. Each of the other pads required to make up the bearing are of similar construction and function similarly. In this case the metal-elastomer laminate functions for substantially frictionless movement in the direction of movement of member 13, parallel to the arcuate interface while due to its inherent stiffness, it will substantially not deflect in the direction of the load pressure, or radially with respect to the arcuate interface. It should be noted that bearing pads of this construction can self-adjust to either direc-

tion of movement of the element 13. Another function accomplished by the laminated arcuate construction of the pad is that of equalizing the load between adjacent pads as load shifts under different conditions i.e. speed, thrust etc.

FIG. 4 illustrates the application of the invention to a cylindrical bearing in which each of the pads 11 is similar to the pad of FIG. 3. Element 19 is the shaft and element 21 is the bearing housing.

FIG. 5 shows the application of this invention to a thrust bearing wherein each of the pads 11 are of the type shown in FIG. 3.

FIG. 6 indicates in a generalized way the fluid pressure distribution between the pad face 11a and the member 13.

It is also to be understood that the material for the face of pad 11 is selected to be compatible with the selected lubricant and on the basis of other factors well known in the art. Moreover, the term metal-elastomer is intended to encompass any elastic-inelastic laminate possessing generally the same properties as the metal-elastomer laminate materials.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

WHAT I CLAIM IS:

1. A hydrodynamic bearing arrangement for supporting a movable load applying member in low-friction relationship in the presence of a lubricating fluid medium, said bearing arrangement comprising at least one bearing pad disposed between said movable load applying member and a relatively stationary support structure, the bearing pad including a swingable face portion disposed adjacent said movable member, and means for supporting said face portion for swinging motion about an axis of swinging motion spaced from said face portion and on the same side of said face portion as said movable member, said face portion of each pad being swingable to a dynamically stable inclined position under the combined influences of friction and load forces acting thereon in the presence of a lubricant fluid.

2. A hydrodynamic bearing arrangement as claimed in Claim 1, wherein said means for supporting the face portion of said pad comprises a relatively stationary base element, each face portion and base element intersecting along an arcuate interface, the centre of curvature of said arcuate interface corresponding to said axis of swinging motion, said interface comprising a relatively low-friction joint between said face portion and said base element.

3. A hydrodynamic bearing arrangement as claimed in Claim 1, wherein said means for supporting the face portion of the pad comprises a relatively stationary base element, the face portion and base element being joined together along an arcuate interface by an elastomeric material that is substantially more rigid in a radial direction with respect to said arcuate interface than in a direction parallel to said arcuate interface, the centre of curvature of said arcuate interface corresponding to said axis of swinging motion

4. A hydrodynamic bearing arrangement as claimed in Claim 3, wherein said elastomeric material is a composite elastomer-inelastic laminate.

5. A hydrodynamic bearing arrangement as claimed in Claim 3, wherein said elastomeric material is sufficiently yieldable in a radial direction with respect to said arcuate interface to provide for load equalization between said bearing pads and to accommodate minor angular displacements of said face portion relative to said base portion.

6. A hydrodynamic bearing arrangement for supporting a movable load applying member in low-friction relationship in the presence of a lubricating fluid medium, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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2 SHEETS

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SHEET 1

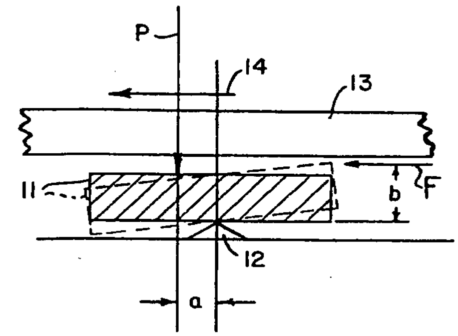

FIG. 1.

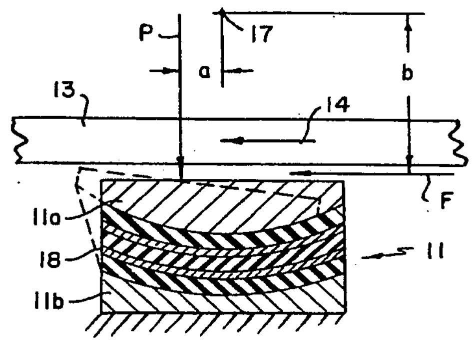

FIG. 3.

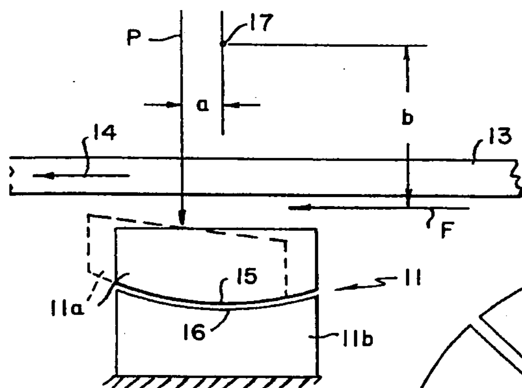

FIG. 2.

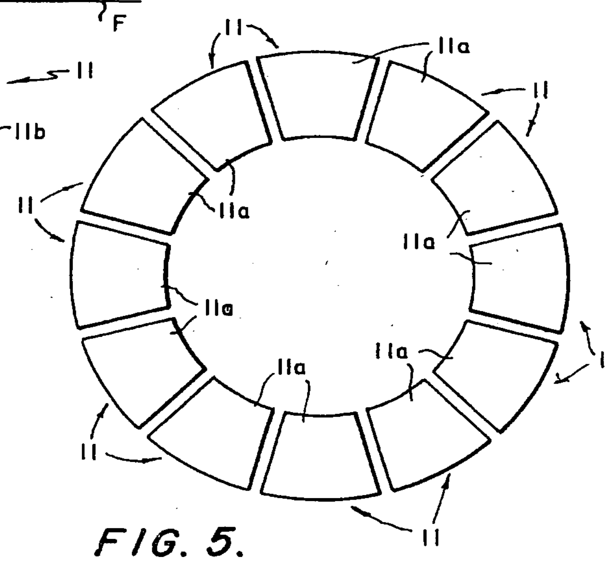

FIG. 5.

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2 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 2

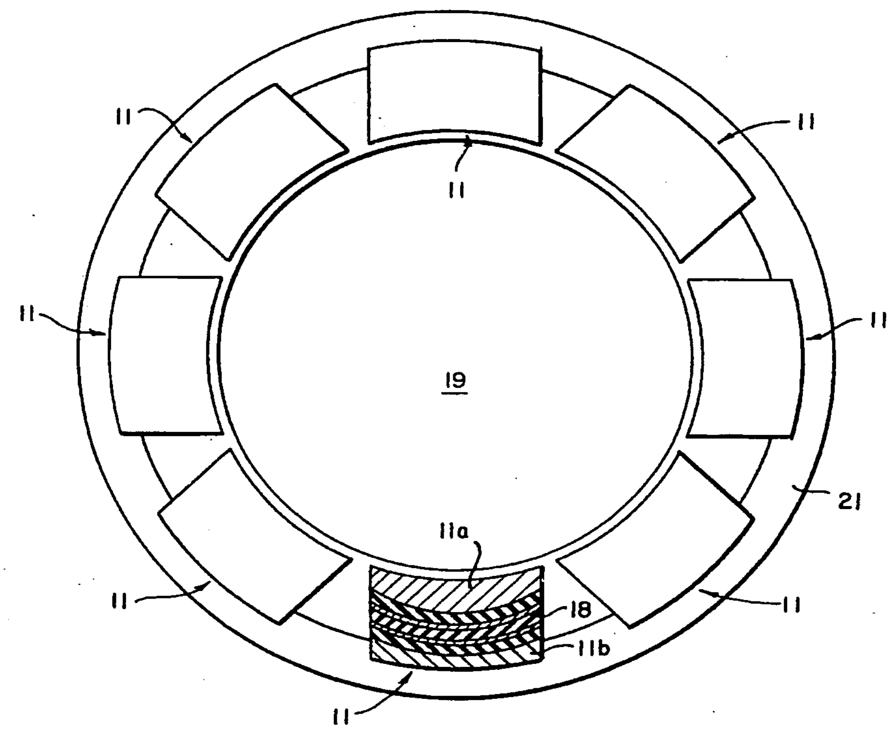

FIG. 4.

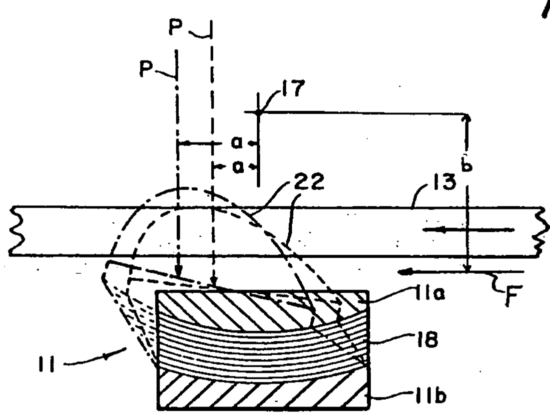

FIG. 6.